2003 Annual Report

A survey of non-indigenous plant species in the northern range of Yellowstone National Park.

Lisa J Rew, Bruce D Maxwell, Frank L Dougher, Richard Aspinall, T. Weaver, Don Despain and Roger Sheley, Montana State University, Bozeman, MT 59717

Project Summary

An inventory/survey is seen as the first of three phases in the management of non-indigenous species (NIS). A survey needs to be designed to obtain an unbiased assessment of NIS extent. Data from the inventory or survey can then be used as baseline data to select patches/populations for monitoring. Monitoring methods should aim to evaluate changes in spatial and temporal extent of NIS, impacts of NIS on the ecosystem, and impacts of management on NIS and surrounding vegetation. Only after following these steps to estimate NIS plant occurrence, extent, dynamics and impacts, can effective management strategies be developed for the currently occurring species as well as new species that may invade National Parks and other wilderness/natural areas.

The overall aim of this project (2001-2004) is to survey the occurrence (presence/absence) of non-indigenous species of plants within the northern elk winter range of the Park. From the field data we will create maps of observed NIS occurrence. Plus, analyze the data for correlations of NIS occurrence with human activities (roads and trails) and environmental variables to aid in the prediction of NIS occurrence in areas not sampled. Thus, our maps will have observed and predicted locations of non-indigenous species. The study is not intended to estimate the extent of populations (density or ha infested).

The northern range covers an area of 152,785 ha which is too large to look for NIS species over the entirety so, in 2001 we focused on identifying which sampling methods provide the highest probability of locating even the rarest plant species. This objective was achieved through computer simulation and field sampling. We have adopted a stratified and adaptive sampling methodology that will maximize the ability to predict occurrence of the NIS and quantify the degree of uncertainty in our predictions. In 2002, two crews sampled 133 transects in the area between Gardiner and Tower Falls. This summer, two crews sampled 121 transects mainly in the areas between Tower Falls and Silvergate. These data are now collated, preliminary analysis and modeling performed, and probability maps of some of the most abundant species generated. Next season we will sample using the transects as before but also sample to validate the predictive model results, and the previously collected data. Permission to perform backcountry transects is requested to sample areas previously denied to us, in order to check and then improve model predictions for such areas.

Project description

Introduction

The United States Department of Interior National Park Service is required by law to keep the 34 million ha designated as National Parks classified as "natural areas". Natural areas must be "unaltered by human activities" as much as possible (U.S. National Park Service, 1996). Maintaining the Parks as "natural areas" includes removal of non-native species. The definition of non-native is "any animal or plant species that occurs in a given location as a result of direct, indirect, deliberate or accidental actions by humans" (U.S. National Park Service, 1996). This definition permits the user to recognize and distinguish between changes to animal and plant distributions caused by natural processes and human influences. In reality this statement needs some further clarification. "Human influence" really refers to disturbance by white settlers, more so in the past century and most specifically in the last 50 years.

Many countries have designated specific areas as "wilderness" or "natural ecosystems" and seek to preserve these in their "pristine" state, however pristine is defined. Taking this desire to "protect and retain" such areas, one can argue from the ecological purist point of view, that all non-indigenous species should be removed. However, this is currently impossible from a practical standpoint. In most cases we do not know which non-indigenous species are present within an ecosystem, their frequency or their distribution pattern; how much their distribution is changing and finally what impact they are having on the endemic ecosystem. It is only armed with all of this information that land managers can effectively target and manage non-indigenous species populations.

The language used to describe the presence and impact of non-indigenous species is often very emotive: "aggressive non-indigenous plants, which spread quickly into natural areas replacing native flora and reducing habitat for native flora and fauna". Often the simple presence of a non-indigenous species is stated as proof enough of present or future environmental damage, particularly if it is a highly competitive species and/or if the increase in the non-indigenous species is associated with the decline of native species. However, Weaver *et al.,* (2001) in a study of the northern Rocky Mountains found that of the 29 most commonly found exotic species the majority were intentionally introduced (e.g. *Phleum pratense* and *Poa pratensis*) and none of the most common were generally considered a noxious weeds.

A number of studies have shown that when non-indigenous species are introduced to environments and ecosystems different from those in which they evolved, they may disrupt the ecosystem processes and alter biological diversity (e.g. Braithwaite & Lonsdale, 1989; Hobbs & Mooney, 1991; see Davis *et al*., 2000 and Mack *et al*., 2000 for reviews). Invasion by a new species is influenced by three factors:

1. ecosystem properties, which could be related to the level or frequency of disturbance;
2. number of propagules entering a new environment (propagule pressure); and,
3. the properties of the invading species (Lonsdale, 1999).

Davis *et al.* (2000) and Davis and Pelsor (2001) offer a new theory, that the fluctuation of resource availability is a key factor in controlling invasion. This theory allows for the integration of resource availability with disturbance and fluctuating environmental conditions.

Disturbance is often suggested as a key factor in enhancing the probability of non-indigenous plant establishment in native plant communities. Natural disturbance has a variety of biotic and geomorphic causes including soil disturbance by fauna, weather related events such as mudflows, floods, wind, fire and geological events such as landslides. Fire is sometimes a quasi-human disturbance if management practices suppress, contain or intentionally ignite them, or if fires are ignited accidentally or intentionally by vandals, whichever way, the natural occurrence of fires has usually been altered. Human disturbance includes construction and use of roads and trails, buildings, utility corridors and campgrounds.

As stated above, the National Park Service has a mandate to preserve the natural systems under their control (National Park Service Organic Act of 1916). There are several phases necessary to achieve this objective:

Phase 1 creating an inventory/survey (documenting occurrence);
Phase 2 monitoring (quantifying changes in distribution or abundance); and,
Phase 3 control or management of non-indigenous species.

To a certain extent these phases can be performed concurrently (Fig. 1). The aim of the current project is Phase 1, development of an inventory/survey program.

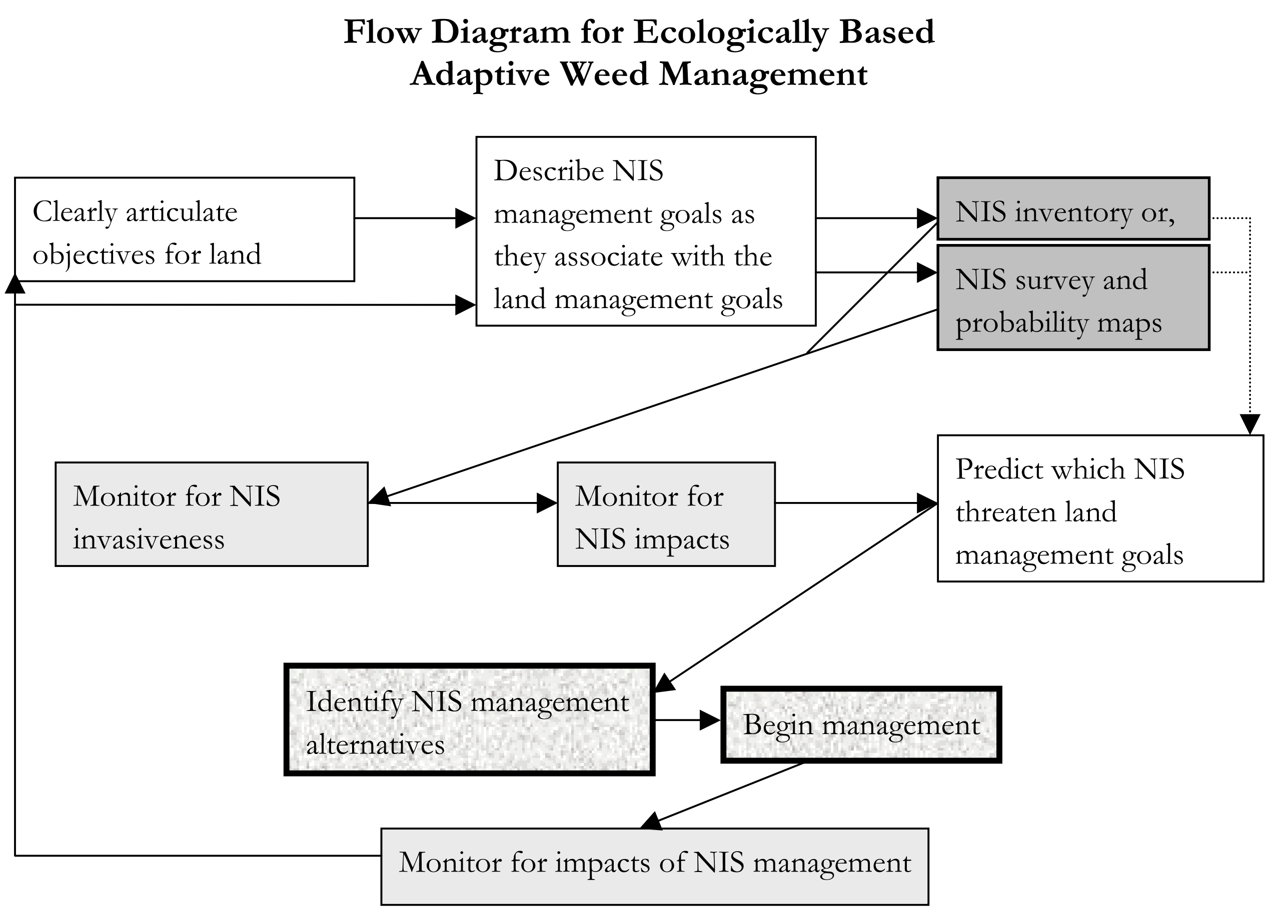

Fig 1 Flow diagram for ecologically based adaptive weed management.

The problem with developing an inventory/survey

Conducting an inventory/survey of non-indigenous plants in a large region where many of the non-indigenous species have infrequent occurrence is a difficult task. The definition of a inventory is a list of all NIS species and their locations in a delineated management area when the entire area can be observed. A survey is defined as a list of NIS species and their locations in a delineated management area when all of the area cannot be observed. A survey requires careful consideration of sampling methods. As the area of the northern range if so large and we cannot sample the entire area we are by definition completing a survey. This term will be used from now on.

Considering the ultimate use of the survey is essential in the design. In the case of the National Park Service, management of NIS is the objective, but because the NIS are relatively infrequent and spread over large areas, it will never be possible to manage all NIS or all their occurrences. Thus, a survey of the NIS and the subsequent assessment of population and metapopulation dynamics must have the objective of creating an unbiased sample in order to prioritize management of those metapopulations that pose the greatest threat to the ecosystem. An unbiased sample requires locating populations or metapopulation over the extent of the environments where they may exist. Therefore, we are reliant upon a survey that maximizes the probability of finding the NIS and simultaneously builds a data set from which models that predict NIS occurrence can be developed to ensure that we represent, through observation or prediction, all environments where the NIS may be found. It is tempting to combine survey and population assessments. If the survey is strictly a means of finding the NIS so that they can be killed, then an estimate of each metapopulation extent in the survey could serve the purpose of knowing approximately how much herbicide/hand-weeding will be required to control the observed metapopulations. However, if the intent of the survey is to maximize the potential of knowing where all of the NIS are located and subsequently using the survey to select a random sample of metapopulations to monitor for an unbiased determination of population dynamics and prioritization of management, then the survey approach that we are suggesting is most appropriate.

Study area

Yellowstone National Park (YELL) covers an area of 899,121 ha (2,220,829 ac). Approximately 1265 plant species have been recorded in YELL of which 187 (15%) are non-indigenous plant species (Whipple, 2001). The proposed study will concentrate on the area within the northern elk winter range of the Park (152,785 ha, 377,379 ac).

Current knowledge of non-indigenous species occurrence

The relative proportional importance of the different forms of disturbance and environmental factors on non-indigenous species establishment and survival has not been quantified. The general perception from the National Park staff involved with NIS surveys and members of this research group was that most infestations occur close to roads, trails and human habitation. From the data collected by YELL park staff in 1998, it was calculated that 278 of 422 (66%) NIS occurrences were less than 100 m from roads or trails, and all observations were made less than 500 m from roads or trails. These data were not collected using a formal sampling strategy and the sites searched were biased by their proximity to roads and trails. Therefore, this information was treated as anecdotal and although considered, the data were not used for any subsequent analysis.

In order to provide a more quantitative understanding of potential factors that influence the occurrence of non-indigenous species a pilot study was performed during the summer of 2001.

Initially a computer simulation was performed to evaluate the best sampling methodology. The chosen methodology was then applied in the northern range of Yellowstone and valley floor of Grand Teton National Parks.

To ensure the best use of the limited funds and time available in the field, a desktop study was conducted to develop the most effective sampling regime. This was performed in ESRI ArcView© GIS using routines developed by Aspinall and Dougher. This implemented several different sampling strategies including simple random sample, random walk, random transects, transects normal to specified linear features, stratified random sampling and regular grid sampling. Additionally, different sampling intensities were evaluated for different infestation levels (frequencies) of non-indigenous plants.

It is assumed that most of the species we are targeting are at a low frequency within the landscape and therefore collecting large numbers of observations is important to provide a reliable estimate of the species occurrence. A large sample combined with an appropriate strategy for estimating geographic distribution is also necessary if the goal is to estimate the distribution of the non-indigenous plant in the landscape. Survey design is, therefore, a tradeoff between collecting a sufficiently large sample to provide reliable estimates of occurrence, and using a sampling strategy that is efficient for both a) field work and b) estimating the geographic distribution of the species.

The simulations and sampling strategies implemented within the GIS allowed us to evaluate which sampling strategy provides the highest number of sample points for the shortest time in the field and, also provides geographic coverage necessary for estimating distribution of the non-indigenous species. Random points or grid intersections for example, are not as efficient for collecting data as random walks or transects since time used moving from one survey location to another location is not used for data collection. Surveying along transects allows data to be collected continuously and a large sample size be generated. Additionally, surveying along transects allows changes in underlying environmental variables to be recorded. This is important for estimating the geographic distribution of the species from the sample data.

If the occurrence of a target species is known to be correlated with an environmental variable, we could stratify the sampling scheme on that variable and improve our probabilities of finding the target (Hirzel and Guisan, 2002). We accepted the assumption that human disturbance in the form of roads and trails increases the chance of finding non-indigenous species, and stratified our sampling using this variable. However, to test this hypothesis we also needed to sample away from roads and trails. Therefore, transects established perpendicular to roads and trails were accepted as the most effective sampling methodology. The use of 2000 m transects allows the importance of other factors to be evaluated, since each transect is sufficiently long to cross a number of cover or habitat types and other environmental transitions.

Collection of field data

In 2001, the position of each transect was randomly selected, prior to arrival in the field, and ran perpendicular to roads or trails. This approach needed to be partially modified for subsequent years to ensure a similar number of data points were collected at all distances from roads and trails. Two kilometer buffers were established around roads, and trails (Fig. 2). The location of transects was still randomly generated but within a set of confines:

- Starting on a road and finishing 2000 m from all roads but at all times the transect runs more than 2000 m from any known trail
- Starting on a trail and finishing 2000 m from all trails but at all times the transect runs more than 2000 m from any known road
- Starting on a road or trail and finishing 2000 m from all roads and trails.

Transects were walked and locations recorded with a GPS (Global Positioning System), by two person teams. Transects were 10 m wide. Trimble Pro XR receivers and GeoExplorer® 3 units were used and the data post-processed to improve accuracy. The coordinate system and projection used was Universal Transverse Mercator (UTM) Zone 12N, WGS 1984 Datum. This projection and datum is the same as used for GIS data maintained by YELL Center for Resources, and the Greater Yellowstone Area Spatial Data Clearinghouse managed and maintained by the Geographic Information and Analysis Center (GIAC) at Montana State University. Transects were walked and information gathered when a target non-indigenous species was located, the habitat type changed or a disturbance feature was reached. The habitat classifications were based on the classifications devised by D. Despain and incorporated into the YELL GIS layers.

In 2002, all data were collected directly into a data dictionary on a GeoExplorer® 3 unit that contained the same data fields as used in 2001, plus additional information on patch parameters and fields required by North American Weed Mapping Association (NAWMA). These included the location of target species, with additional information on density (in predefined classes of 0, 0-1, 1-11, 12-32, 33-100, 101-316, 317-1000 and >1000 m^{-2}), percentage cover m^{-2}, length (m) and width (m) of infestation, and spatial pattern type. Percent cover estimates was collected in accordance with NAWMA. Environmental variables included; climax habitat type, dominant vegetation cover species (four species), aspect, topography and disturbance. Additional data fields included NAWMA's "Values at risk" and "Ecological status of site/survey unit" and, time and date.

Fields that were not collected but could be added to the database at a later stage include information about the site/region, I&M network, park unit, state, county, ownership, type of survey, and non-indigenous NIS plant and ITIS code all of which can be added to the database in the office.

The National Park Service has historically recorded habitat types rather than dominant vegetation/cover types. For the purpose of evaluating the environment where non-indigenous species are more likely to invade it is necessary to know the current dominant species or successional stage, as well as the climax vegetation (habitat type). Information will continue to be recorded on both the dominant cover and climax vegetation. Classification already developed and used by park staff will be used.

In 2003, all data were collected directly into the data dictionary on a GeoExplorer® 3 unit that contained the same data fields as used in 2002. A few changes were made to the data dictionary to improve data collection efficiency in the field.

Results of field work

During 2001, 42 transects were walked in the northern range with an overall sampled length of 86,053 m x 10 m wide. Nine species were targeted; *Bromus inermus, Bromus tectorum, Centaurea maculosa, Cirsium arvense, Chrysanthemum leucantheum, Cynoglossum officinale*, *Linaria dalmatica, Melilotus officinalis* and, *Phleum pretense*.

In 2002, 116 transects were walked in the northern range with an overall sampled length of 196,189 m x 10 m wide. An additional 17 * 2000 m long transects were completed along trails and rivers. Sixty-two species listed on the YELL priority list (Appendix 1) were targeted. 23 of the 62 were observed in the field. Six of these species were observed over 1% of the surveyed area; *Phleum pretense, Bromus tectorum, Cirsium arvense, Poa pratensis, Bromus inermis,* and *Linaria dalmatica*.

In the 2003 season, 121 transects were completed that covered 212,315 m x 10 m (Fig. 2). Again, the sixty-two species were targeted but only 16 of these species were recorded in the transects (Table 1). Seven of these species were recorded with occurrence rates of more than 1% over the study area. *Phleum pratense* had a percentage occurrence of 32.1% (Fig. 3), which was more than any other species but not surprising considering that it was intentionally introduced to the park in the early 1900's. *Poa pratensis* occurred over 14.1% of the surveyed area (Fig. 4), *Alyssum desertorum* had an occurrence of just over 5% (Fig. 5), *Cirsium arvense* had an occurrence of 4.7% (Fig. 6), *Bromus tectorum* occurred over 3.1% of the studied area (Fig. 7), and *Bromus inermis* (Fig. 8) and *Trifolium hybridium* (Fig. 9) had occurrences of 2.8 and 1% respectively. Percentage occurrence over the infested area was generally considerably than 1% for all other species (Table 1).

Infestation length and width measures were estimated by pacing or visual determination from a central location within the patch when the patch size was small enough. When the length of the patch was too large to visually perceive or pace from a single location, the start and end of the patch length along the transect was recorded with GPS. The total length was determined by data analysis in the field. (Patch widths were estimated up to a width of 64 m).

Transects were allocated to ensure that each ended at least 2000 m from a road, trail or road and trail. Once entered into the GIS, distance from road and trails was re-calculated for each transect and the distance partitioned into 10 m intervals from both roads and trails for further analysis. The patterns observed for those species with more than 1% occurence have been plotted and show a decline with distance from road/trail. The presence of *A. desertorum, B. inermis, B. tectorum, C. arvense, P. pretense, P. pratensis* and *T. hybridum* are shown in Fig. 10. The correlations between the percent populations of *T. hybridum* and *C. arvense* and distance to roads and trails is less distinct than for the other illustrated species, most likely due to the dispersal mechanisms and introductory history of those species.

Table 1. Number of observations and percentage occurrence within the area studied in 2003.

Species	Number of observations	Average infestations, when present				% occurrence
		Length (m)	Width (m)	% cover	Density (m)	
Phleum pratense	187	351	> 64	4	6	32.112
Poa pratensis	192	168	59	2	5	14.146
Alyssum desertorum	54	189	48	7	16	5.020
Cirsium arvense	231	36	30	6	5	4.663
Bromus tectorum	71	88	39	10	15	3.134
Bromus inermis	76	72	49	20	18	2.810
Trifolium hybridum	45	39	41	16	6	1.005
Trifolium repens	25	22	24	13	6	0.324
Melilotus officinale	10	17	> 64	6	3	0.105
Cynoglossum officinale	6	3	3	10	3	0.014
Potentilla recta	5	5	24	2	1	0.011
Medicago lupulina	8	2	48	4	3	0.008
Verbascum thapsus	5	20	26	2	4	0.005
Cirsium vulgaris	7	5	4	8	5	0.004
Poa bulbosa	3	100	48	4	3	0.003
Trifolium aureum	5	1	2	23	6	0.003

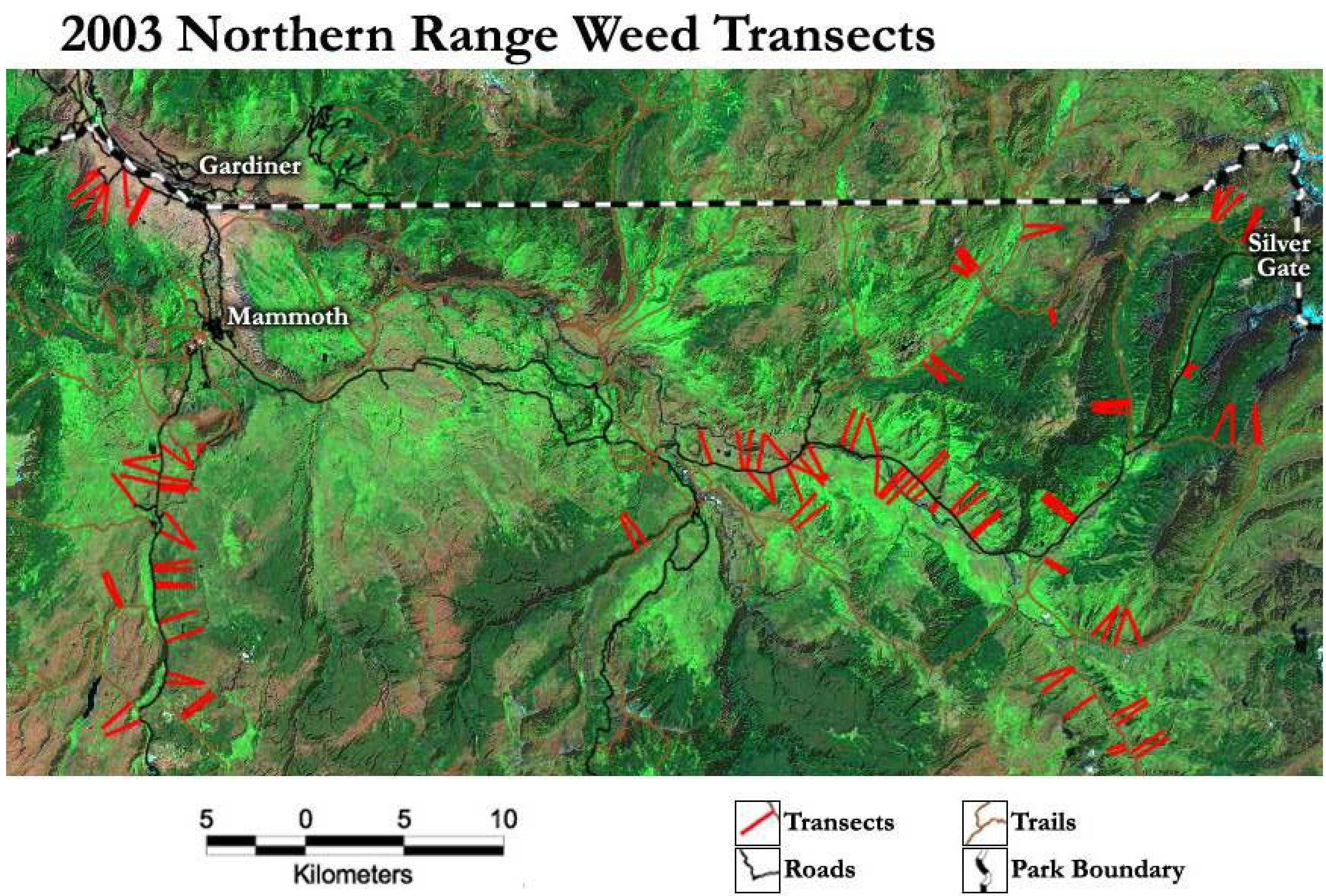

Fig. 2. Locations of all transects walked in the northern range of YELL in 2003.

2003 *Phleum pratense* occurrence

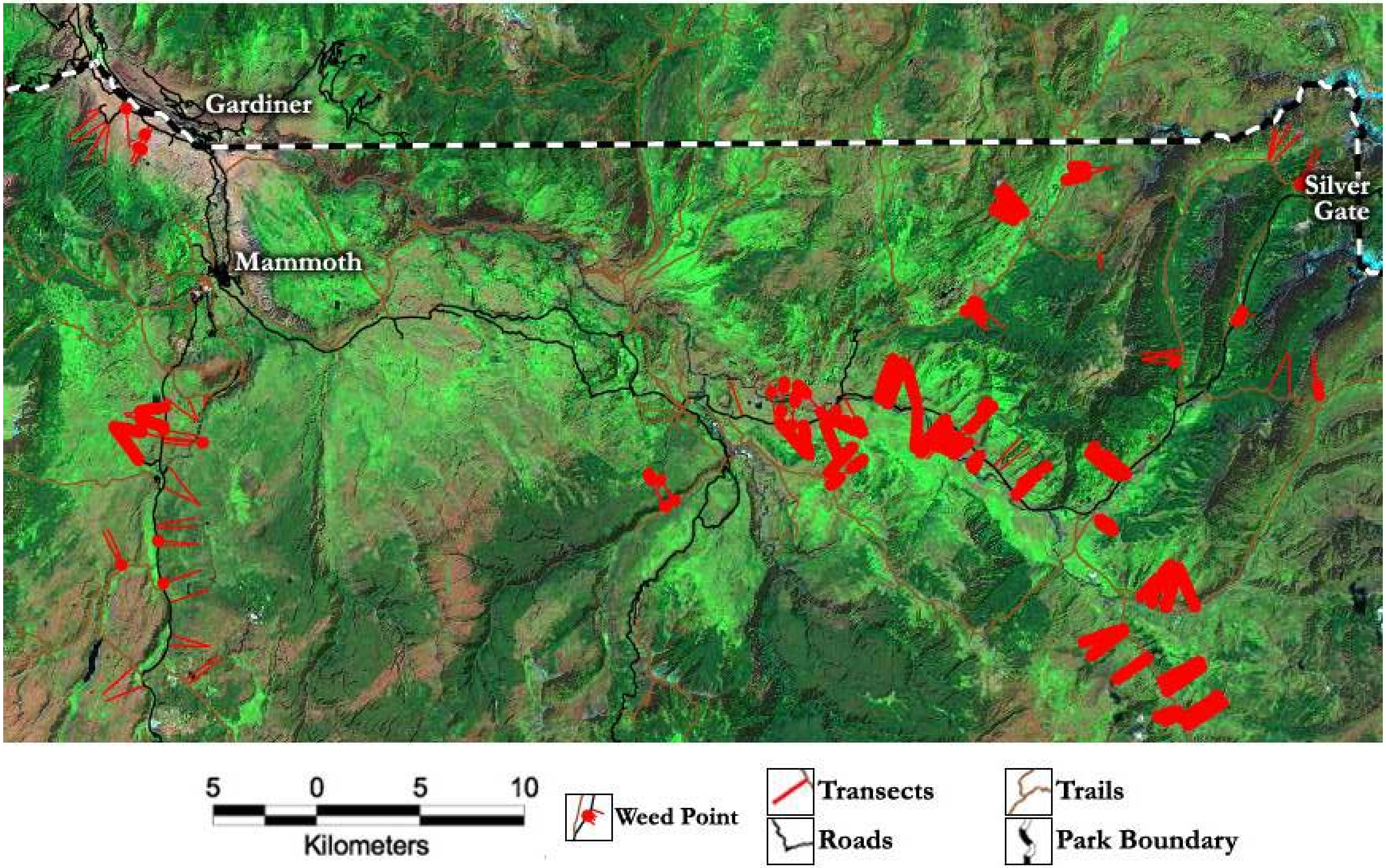

Fig. 3. Observed presence of *Phleum pretense* in the northern range of YELL in 2003.

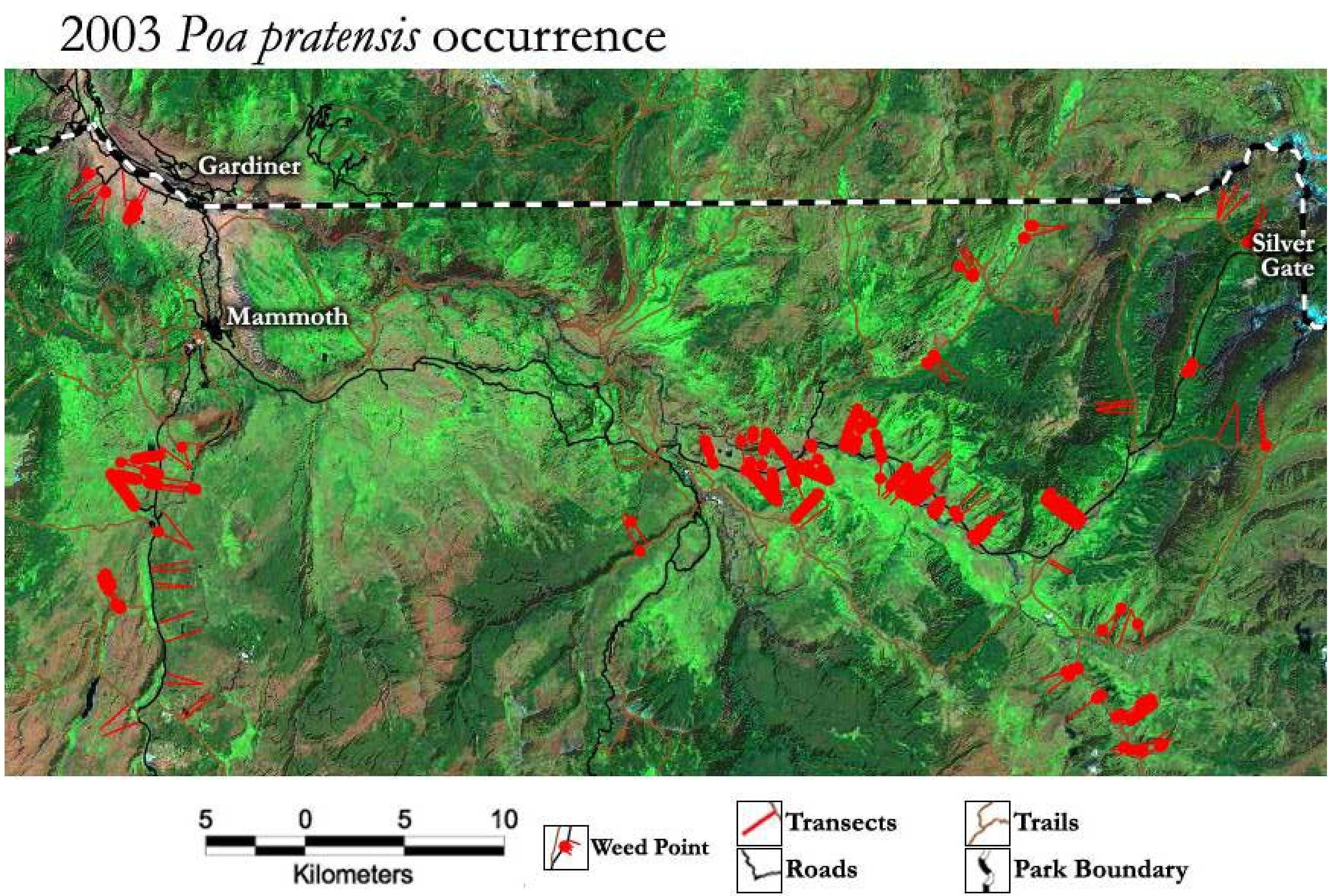

Fig. 4. Observed presence of *Poa pratensis* in the northern range of YELL in 2003.

2003 *Alyssum desertorum* occurrence

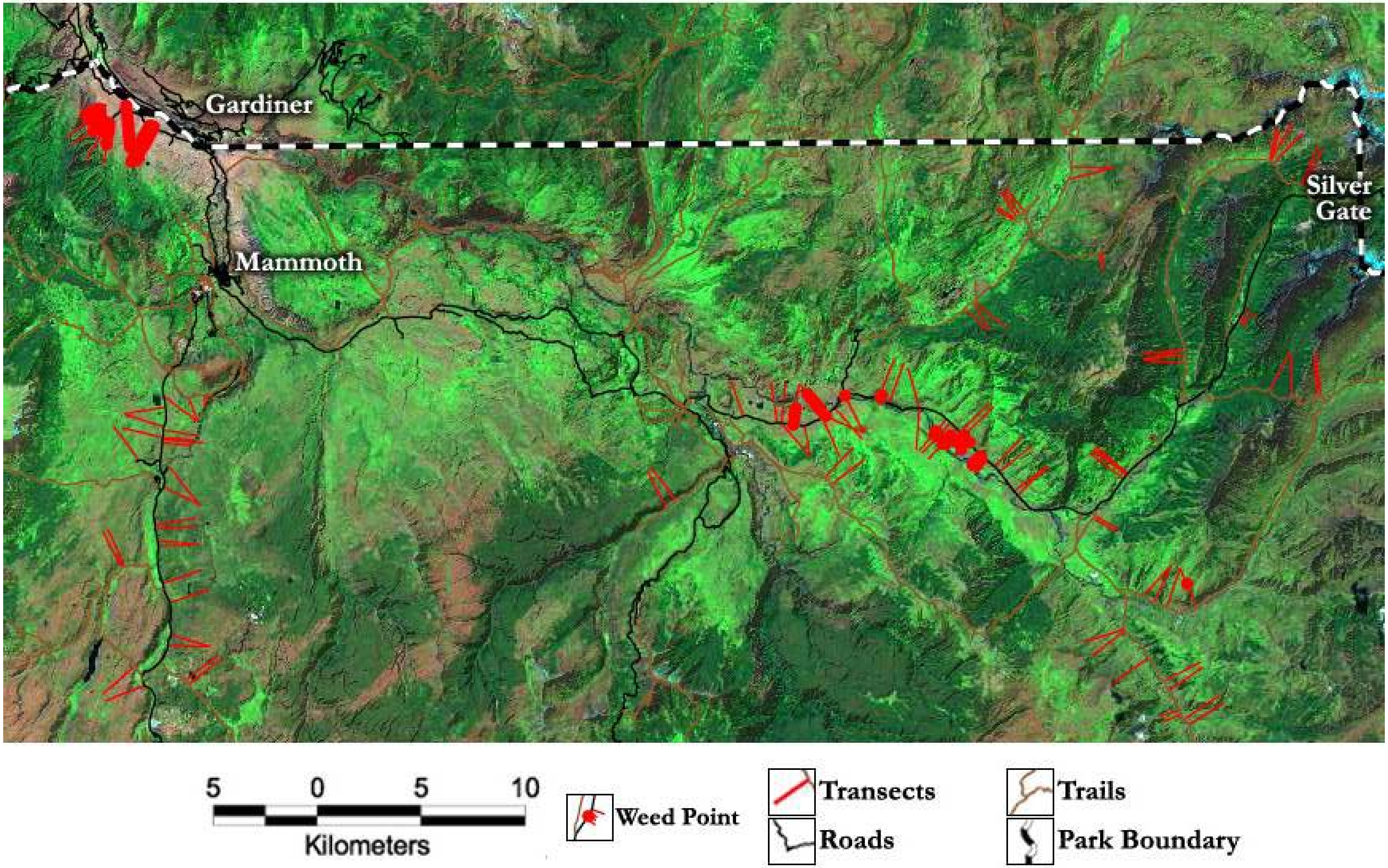

Fig. 5. Observed presence of *Alyssum desertorum* in the northern range of YELL in

2003 *Cirsium arvense* occurrence

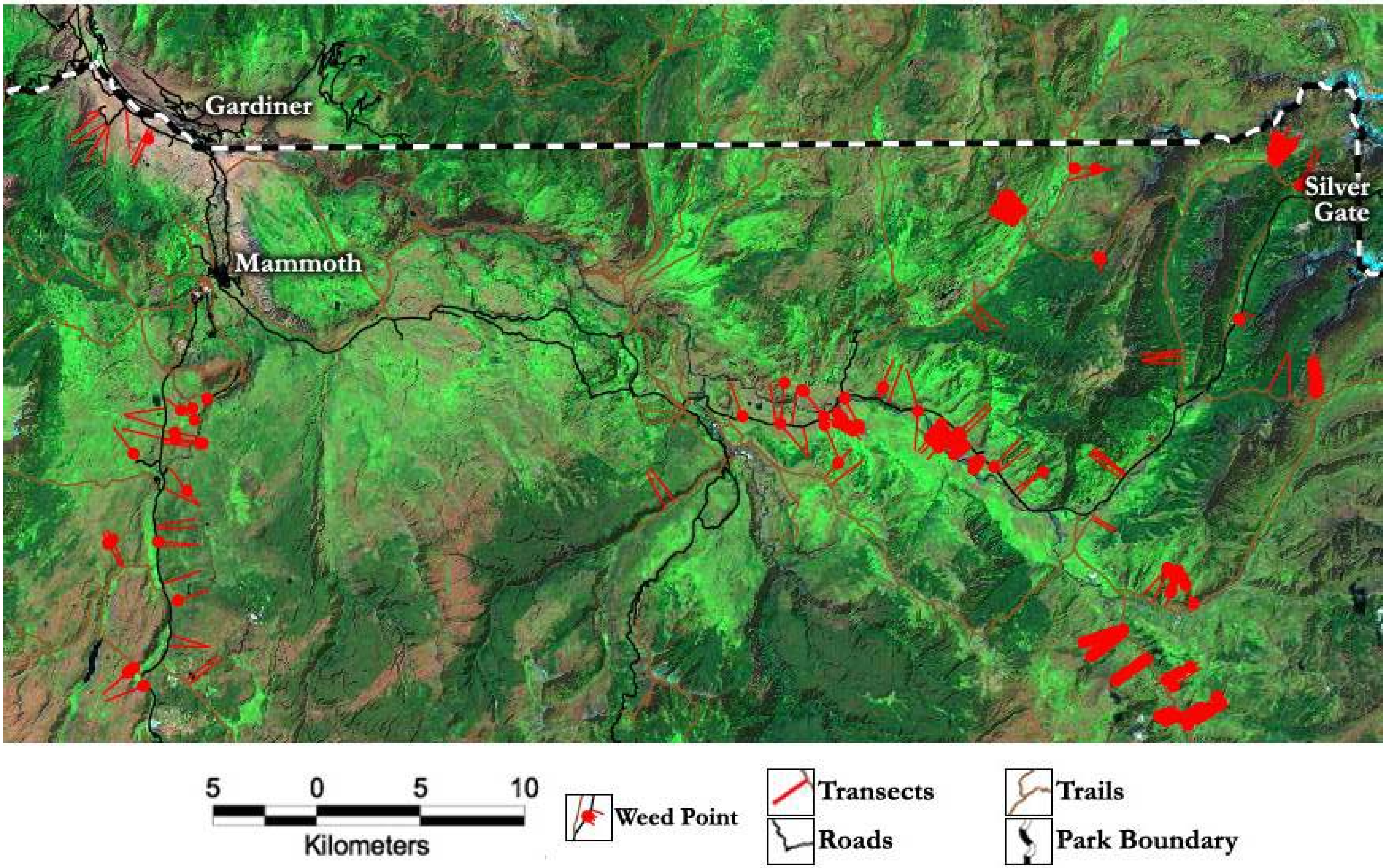

Fig. 6. Observed presence of *Cirsium arvense* in the northern range of YELL in 2003.

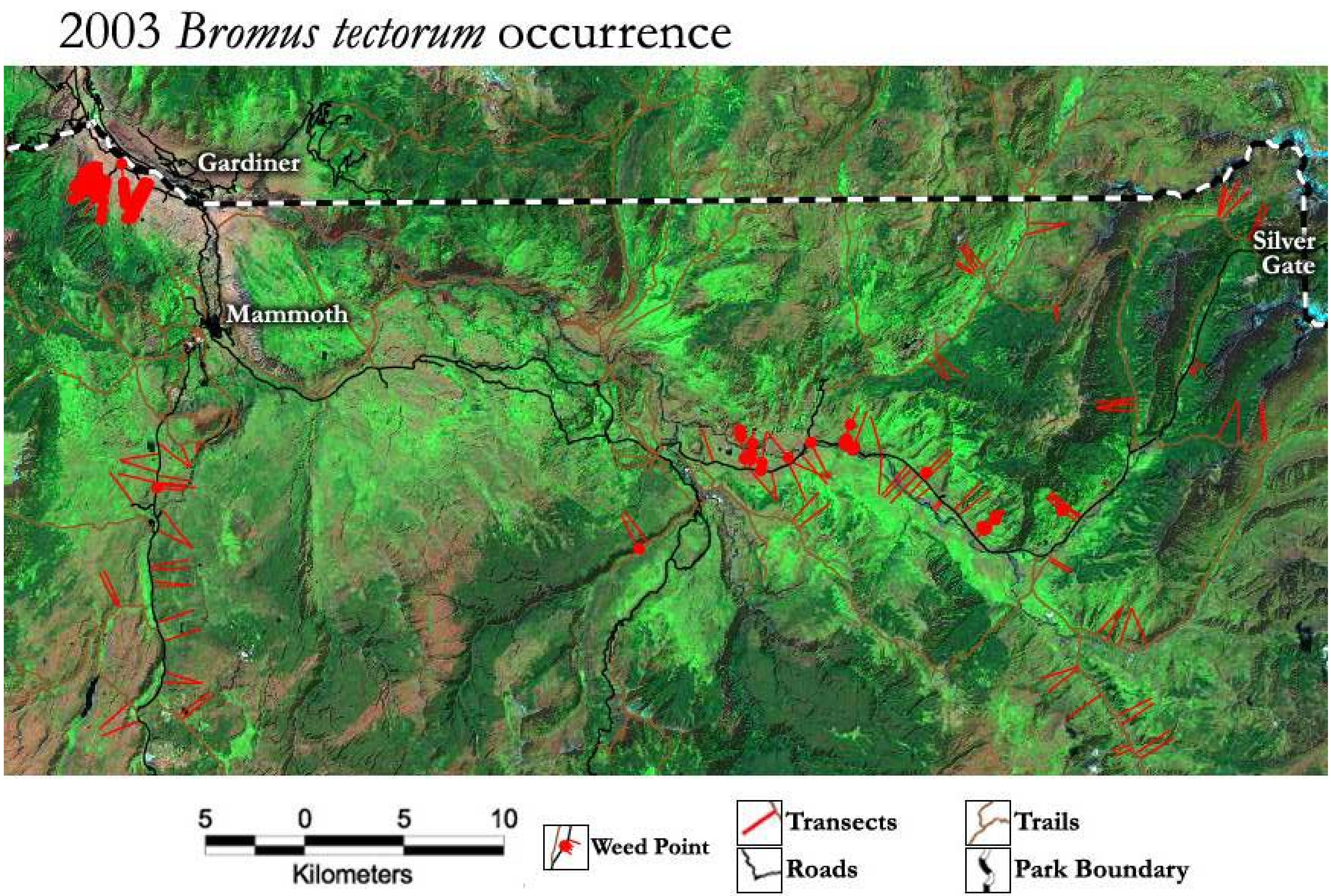

Fig. 7. Observed presence of *Bromus tectorum* in the northern range of YELL in

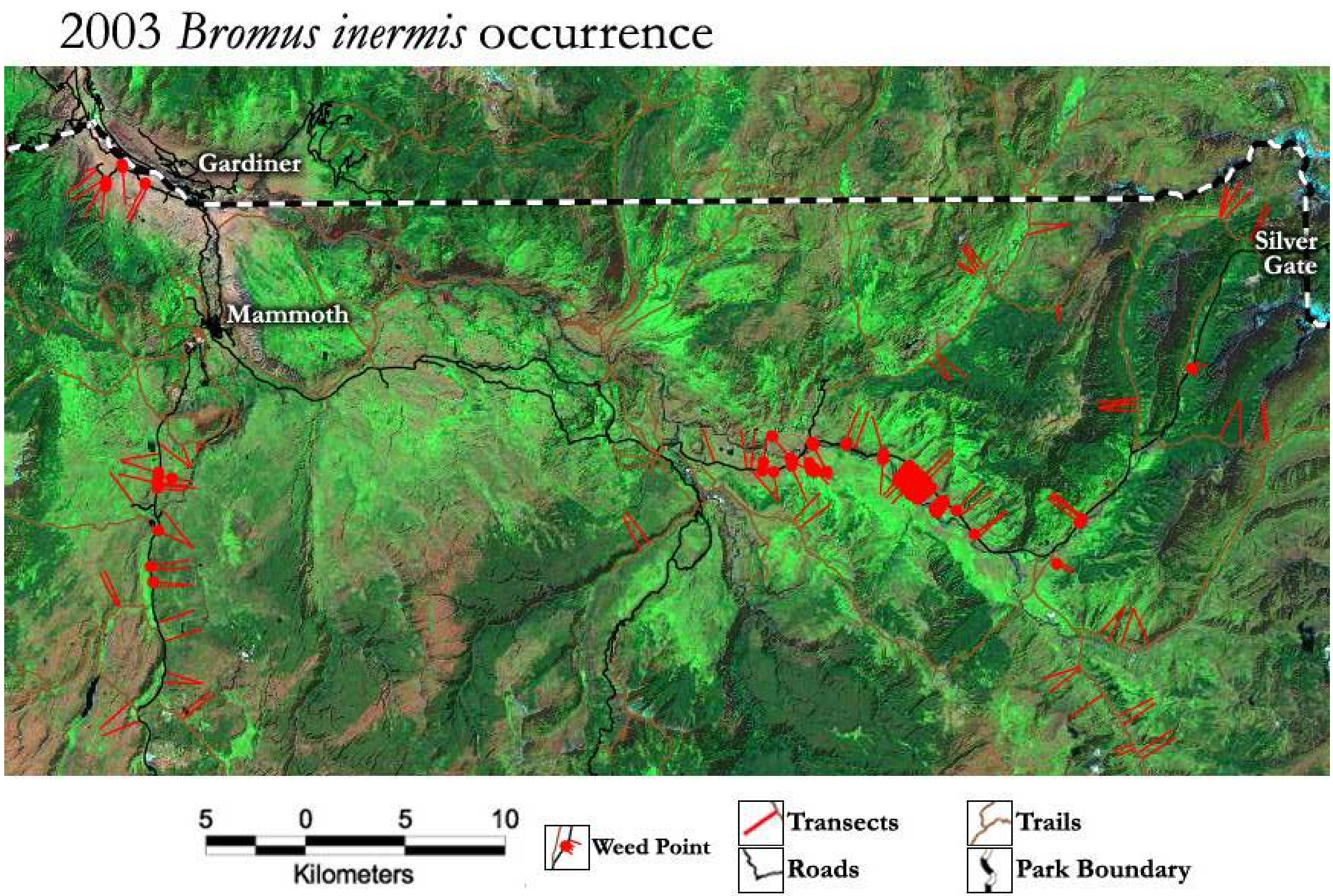

Fig. 8. Observed presence of *Bromus inermis* in the northern range of YELL in 2003.

2003 *Trifolium hybridum* occurrence

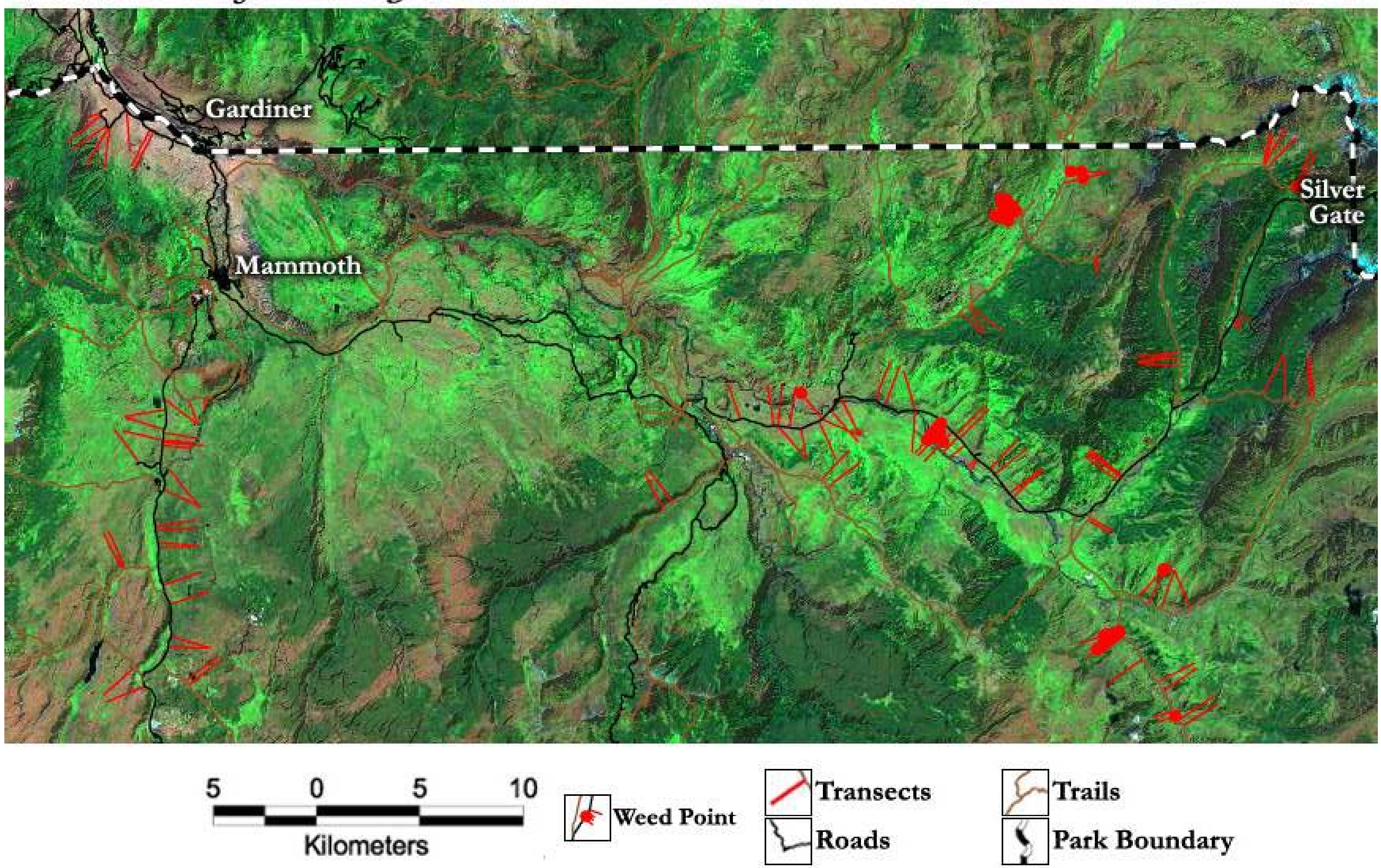

Fig. 9. Observed presence of *Trifolium hybridum* in the northern range of YELL in

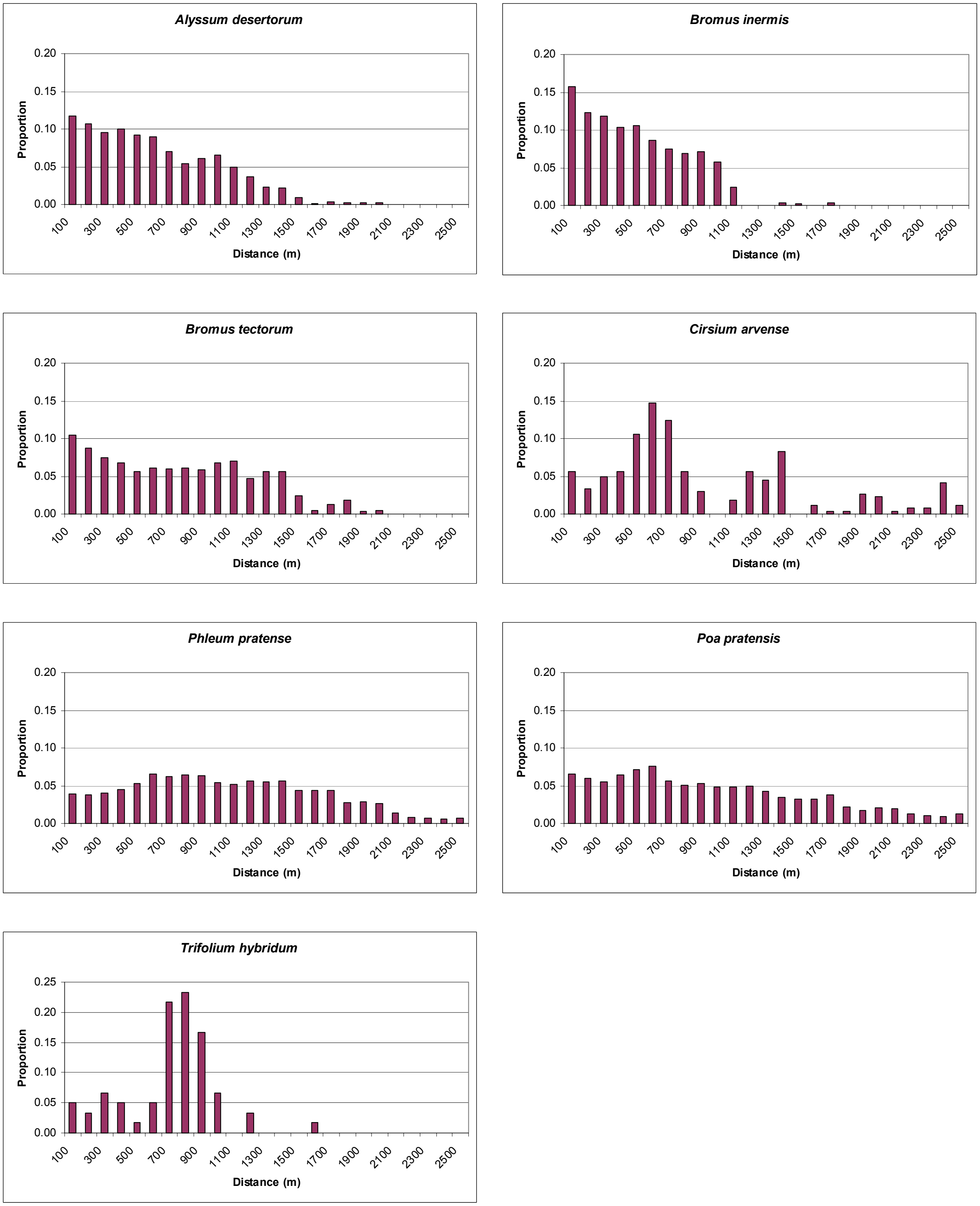

Fig. 10. Proportion of selected species observed within 100 m intervals of roads/trails in the northern range of Yellowstone National Park in the 2003 season.

2004 field season

For the 2004 field work we will collect more data on NIS occurrence in three ways. Transect data will be collected as in previous years, a small number of transects or data points will be revisited to check the validity of the data, and some areas will be sampled intensively to check the accuracy of the predictive models.

It has been noted that though the 2000 m transects do characterize the majority of the land area in the northern range of YELL, there are still sizeable portions of land beyond two kilometers from roads and trails that remain underrepresented by this sampling scheme, particularly south of Blacktail and east of the Gardner river. We seek permission to complete multi-day transects through one or more of these underrepresented areas which are far from any back-country campsites.

References

Aspinall R (1992) An inductive modeling procedure based on Bayes' theorem for analysis of pattern in spatial data. *Int. J. Geog. Systems*, 6, 105-121.

Benjamin P (in preparation) NIS mapping and database development guidelines for the national park service, Intermountain region (IMR)

Braithwaite RW, Lonsdale WM & Estbergs JA (1989) Alien vegetation and native biota in tropical Australia: the spread and impact of *Mimosa pigra*. *Biol Cons.*, 48, 189-210.

Cooksey D, & Sheley R (1997) Montana noxious NIS survey and mapping system. Montana State University Extension Service, MT 9613.

Davis MA & Pelsor M (2001) Experimental support for a resource-based mechanistic model of invasibility. *Ecology Letters,* 4, 421-428.

Davis MA, Grime JP & Thompson K (2000) Fluctuating resources in plant communities: a general theory of invisibility. *J. of Ecology*, 88, 528-534.

Hill MO (1973) The intensity of spatial pattern in plant communities. *J. of Ecology*, 61, 225-235.

Hirzel & Guisan (2002). Which is the optimal sampling strategy for habitat suitability modeling. *Ecological Modeling*.

Hobbs RJ & Mooney HA (1991) Effects of rainfall variability and gopher disturbance on serpentine annual grassland dynamics. *Ecology*, 72, 478-491.

Lonsdale WM (1999) Global patterns of plant invasions and the concept of invisibility. *Ecology*, 80, 1522-1536.

Mack RN, Simberloff D, Lonsdale WM, Evans H, Clout M & Bazzaz FA (2000) Biotic invasions: causes, epidemiology, global consequences, and control. *Ecol. Appl.*, 10, 689-710.

Rew LJ, Alston CL, Harden S & Felton WL (2000) Counts versus categories: choosing the more appropriate NIS scoring method. *Australian Journal of Experimental Agriculture*, 40, 1121-1129.

U.S. National Park Service 1996 (Online) Preserving our natural heritage – a strategic plan for managing invasive non-indigenous plants on national park system lands. http://www.nature.bps.gov/wv/strat_pl.htm

U.S. National Park Service Organic Act of 1916 (Online) (Exerts from) http://www.nps.gov/legacy/nomenclature.html

Whipple JJ (2001) Annotated checklist of exotic vascular plants in Yellowstone National Park. *West. North Am. Nat.*, 61, 336-346.

2004 Budget

Study Plan Budget for northern range of Yellowstone- ACTUAL FUNDS

	2004
Labour	
Costs	21915.71
Benefits	5230.65
Total	**27146.36**
Travel	
Per diem - accommodation	1300.00
Per diem - sustenance	2208.00
Mileage (2000miles/month @ .32 c)	2592.00
Vehicles maintainance	1000.00
Total	**7100.00**
Supplies	1500.00
Total	**1500.00**
Sub-total	**35746.36**
Indirect costs @ 15%	**5361.95**
2004 Grand Total	**41108.31**

Project timetable	Jan	Feb	Mar	Apr	May	June	Jul	Aug	Sept	Oct	Nov	Dec
Project implementation						**2002**						
Advertise positions												
Reserve accommodation												
Purchase GPS, rent vehicles etc.												
Apply for Research Permit												
Program GPS												
Phase I - Non-indigenous survey												
Field Assistants commence												
GPS and botanical initiation (1 week)												
Data collection												
Data collation and analysis												
Data collated												
Data analysis & report												
Project implementation						**2003**						
Advertise positions												
Reserve accommodation												
Apply for Research Permit												
Program GPS												
Phase I - Non-indigenous survey												
Field Assistants commence												
GPS and botanical initiation (1 week)												
Data collection												
Data collation and analysis												
Data collated												
Data analysis & report												
Project implementation						**2004-2005**						
Advertise positions												
Reserve accommodation												
Apply for Research Permit												
Program GPS												
Phase I - Non-indigenous survey												
Field Assistants commence												
GPS and botanical initiation (1 week)												
Data collection												
Data collation and analysis												
Data collated												
Final report due May 2005												

Appendix 1 Non-indigenous NIS of interest for Yellowstone National Park

Watch List: Exotic species not documented/established in the park. The goal is to prevent establishment through staff education, early detection, and eradication. Those species noted with an asterisk (*) have been found in the park, but were removed prior to seed dispersal.

1. *Arctium lappa**	(great burdock)
2. *Arctium minus**[1]	(common burdock)
3. *Centaurea pratensis**	(meadow knapNIS)
4. *Centaurea solstitialis*	(yellow starthistle)
5. *Chondrilla juncea*	(rush skeletonNIS)
6. *Crupina vulgaris*	(common crupina)
7. *Isatis tinctoria**	(dyer's woad)
8. *Lepidium latifolium*	(perennial peppergrass)
9. *Lythrum salicaria*	(purple loosestrife)
10. *Onopardum acanthium**	(scotch thistle)
11. *Senecio jacobaea**	(tansy ragwort)

Priority 1: Species that have produced seed in the park, but populations are small and limited in number. These species have a high probability for eradication with continued annual monitoring and treatment. They are also the most cost effective species to control (<1 acre infestation).

1. *Astragalus cicer*	(chick-pea milkvetch)
2. *Carduus acanthoides*	(plumeless thistle)
3. *Centaurea diffusa*	(diffuse knapNIS)
4. *Centaurea repens*	(Russian knapNIS)
5. *Chorispora tenella*	(blue mustard)
6. *Conium maculatum*	(poison hemlock)
7. *Dianthus armeria*	(grass pink)
8. *Euphorbia esula*	(leafy spurge)
9. *Hyoscyamus niger*	(black henbane)
10. *Potentilla recta*	(sulfur cinquefoil)
11. *Ranunculus acris*	(tall buttercup)
12. *Tamarix chinensis*	(tamarisk)
13. *Tanacetum vulgare*	(tansy aster)
14. *Trifolium aureum*	(yellow clover)

Priority II: Aggressive invaders, some of which are well established in some localities making eradication impractical (identified by •), but most are confined to relatively small areas at specific locations. Containment will be the primary goal for these species in established infestations, and as funding permits as a secondary goal, annual control to reduce seed production with possible future eradication. Individual plants or small infestations away from core infestation areas will be a high priority for aggressive control. Control efforts have a high probability of successfully limiting the spread, and will be undertaken. Monitoring of and for these species should by frequent and regular.

1. *Berteroa incana*•	(berteroa)

[1] Only basal rosettes have been found, so identification to species is uncertain

2. *Cardaria* spp.[2] (whitetop)
3. *Carduus nutans* (musk thistle)
4. *Centaurea maculosa*• (spotted knapNIS)
5. *Chrysanthemum leucanthemum*• (oxeye daisy)
6. *Cirsium vulgare* (bull thistle)
7. *Convolvulus arvensis* (field bindNIS)
8. *Cynoglossum officinale*• (houndstongue)
9. *Hieracium auranticum* (orange hawkNIS)
10. *Hieracium caespitosum* (yellow king devil)
11. *Hieracium floribundum* (glaucous king devil)
12. *Hieracium flagellare* (whiplash hawkNIS)
13. *Hypericum perforatum* (St. Johnswort)
14. *Linaria dalmatica*• (Dalmatian toadflax)
15. *Linaria vulgaris*• (yellow toadflax, butter and eggs)
16. *Melilotus albus* (white sweet clover)
17. *Melilotus officinalis*• (yellow sweet clover)
18. *Silene vulgaris* (bladder campion)
19. *Sonchus arvensis* (perennial sow-thistle)
20. *Verbascum thapsus* (wooly mullein)
21 *Veronica biloba* (bilobed speedwell)

Priority III: Aggressive exotics, which are dispersed over large areas of Yellowstone and have deleterious effects on the park ecosystem. Control efforts are likely to be ineffective and costly. However, work may be done to confine the spread of these plants in sensitive areas. Monitoring would be beneficial, but will come after Priorities I & II.

1. *Alyssum desertorum* (desert elyssum)
2. *Bromus inermis* (smooth brome)
3. *Bromus tectorum* (cheatgrass, downy chess)
4. *Cirsium arvense* (Canada thistle)
5. *Elymus repens* (quackgrass)
6. *Medicago lupulina* (black medic)
7. *Phleum pratense* (common timothy)
8. *Poa* spp.[3] (bluegrass)
9. *Trifolium hybridum* (alsike clover)
10. *Trifolium repens* (white clover)

Priority IV: Exotics, for which little or no control efforts are foreseen. Even though many of these plants displace native vegetation, control of high priority species takes precedence. Limited monitoring actions may be undertaken. Approximately 134 species fall into this category. None of the plants in this category are listed noxious by the surrounding states.

---

[2] *Cardaria chalepensis, Cardaria draba,* and *Cardaria pubescens*
[3] *Poa annua, Poa bulbosa, Poa compressa, Poa palustris,* and *Poa pratensis*